Krause, Karl-Heinz; Linke, Stefan; Müller, Hans-Joachim and Mußlick, Michael

Simulations show air the way - the intelligent stable ventilation

Ventilation companies are asked by farmers to arrange the stable so that the target number of animals can be housed. The companies take the DIN 18910 as orientation. Therewith the amount of air is known to be moved through the stable in order to transport the thermal and harmful loads from inside to outside. The guidance of air is regulated not in particular. Tabulation libraries gives guide values for e.g. air jet behaviour etc. Experiences grasp. Within companies the learning by mistakes help to try to avoid the same error when working for the next farmer. That there is a forsighted way to get knowledge about the fluid flow behaviour by numerical simulation is neglected by nearly all ventilation companies. At every stable design the customer, that is the farmer, should be told what he can expect. Here computational simulation might lead to a solution. This way will develop into the state of technology in the future. In the following an air guiding constellation for a fattening pig compartment is described, that reduces the emission from the stable and enhances the animal behaviour persistently.

Keywords
stall climate, air guidance, emission behaviour, ammonia concentration, simulations

Abstract
Landtechnik 64 (2009), no 1, pp. 54 - 56, 6 figures, 6 references

In Germany the DIN 18910 determines the volume rate of animal houses but not the air guidance.In order to reduce ammonia emission filter techniques are propagated. The lack of space at a great piggery was the reason to develop a new partial underfloor suction with an additional small filter in contrast to the conventional complete filtering of the exhaust air.

Numerical simulations serve as basis to describe the emission behaviour inside a barn with the corresponding effects to outside. May it be complicated it is possible to make statements about the fate of airborne substances. Ammonia, odour, germs and dust are of interest. In simulations ammonia is taken into account only because of measurement reasons. If it is known how ammonia is distributed in the stable then you can influence the distribution of ammonia and odour [1].

Declared objective: reduction of odour and ammonia

The environment situation beside a large plant of animal keeping in Nordhausen (Thuringia), see figure 1, demands an odour emission reduction. Two approaches exist: once the abatement of the disposal of matters from the plant, see figure 2, for the other the dilution of the exhaust air with guidance by elevated sources. Presently the second concept is pursued. Meanwhile the first concept is used in another plant: emission reduction by a partially filtered underfloor suction [2]. With a component airflow suction in the magnitude of the winter flow rate an abatement grade of ammonia emission is reached, which can be 40 % and more in dependency of the ventilation design.

Validation of findings

Concepts of stable ventilation increase by great plants of animal keeping in greater dimensions than by single plants of a farm of conventional character. The worry about bad invest-

ment explains the willingness to make further experiments at great plants more than at single plants. The physic of barns remains untouched. It is the same.

If new findings are desired barn systems are to be altered and the effects are to be measured. „Who is measuring is on the track of truth, only." Measurements in the area of animal keeping are not without problems because there are no clear-cut borderlines. As published in [3] the proof that the emission depends on the animal mass succeeds until 80 %, only. If more different statements of the emission behaviour in a barn are wanted the question may be allowed how meaningful are spot measurements in the original system.

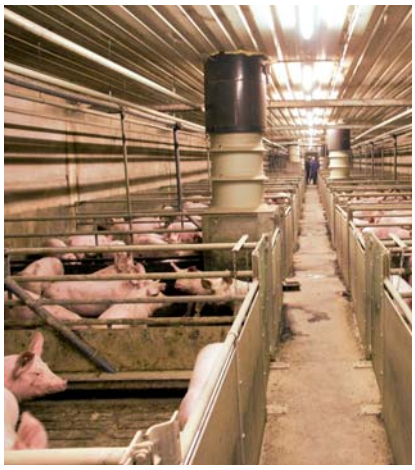
It suggest itself to change to a smaller scale of physical models. In laboratory the emission behaviour is better controllable than in the original plant. Statements with regard to area covering data are simpler to realize, compare figure 3, e.g. in view to the ammonia concentration in a cut of the barn. General statements are reachable that cannot be gained in the original barn. So pattern of flow behaviour can be shown, that deepen the general knowledge of emission, figure 4. In an exemplary fashion it is demonstrated how particles find the way to the exhaust shaft during suction over floor. With the reduction of scale some restriction are connected to similar mechanics [5].

It is quite different when the third kind of recording physical events is selected, the numerical description of the fluid mechanics events: here the restrictions are given by the spatial resolution of the fluid flow space. The results of experiments can be „repeated" in the model and in the original barn. What does this mean? If the numeric is able to realize the events in each scale (in figure 5 and figure 6 the model experiments are tested by numerical simulation) then the numeric can predict what will happen at special changes. That means the numerical simulation technique is a constructive method for barn design. The numerical simulation technique must not prove itself but the barn design by ventilation companies based on concepts of their own must be subject to the general control of the targets of environmental protection, animal welfare and efficiency of energy use. A process of rethinking must start.

Fig. 1

Satellite picture of the stall complex. Big area filters cannot be used because of the low distances between the single stalls. A specially taylored solution is to be searched.

Fig. 2



View into the stable of investigation of the van Asten Tierzucht along the feed-way.

Instruction to act in practice

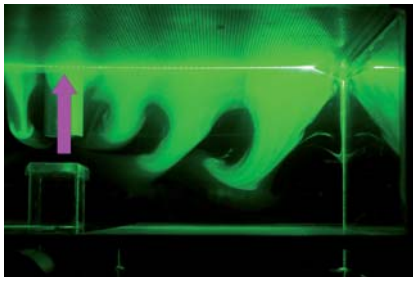
Each keeping of animals should be proved to the effects with regard to environment and animal protection apriori whether new planned or altered [6]. At that the concepts of stable ventilation come to the fore because the ventilation determines the release of substances during 24 hours per day.

Ventilation companies must accept the challenge of adjustment. The hint that ventilation is the way that always be done it is not sufficient with view to the today's global situation and the local requests. The companies must be able to prove what will develop by their measures.

Fig 3

Model stable on the scale of 1:20. To be seen are the suction tubes for ammonia above the slatted floor.

Fig. 4



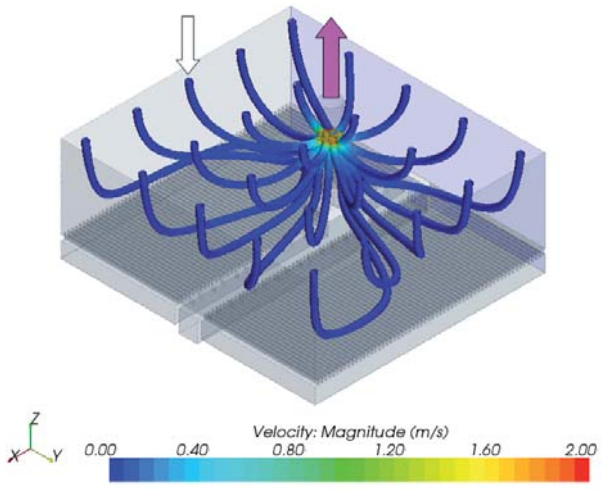
Laser light cut of the smoke gas sucked through the pore ceiling into the (purple arrow) the off-gas duct.

Summary

The international agreements to the reduction of ammonia emission of the plants of keeping animals can be realized when the air guiding concepts are altered. To append filters to the plants of keeping animals is not an intelligent solution of the stable ventilation. The emission of pig fattenings can be reduced by air guiding concepts more than the demanded measure.

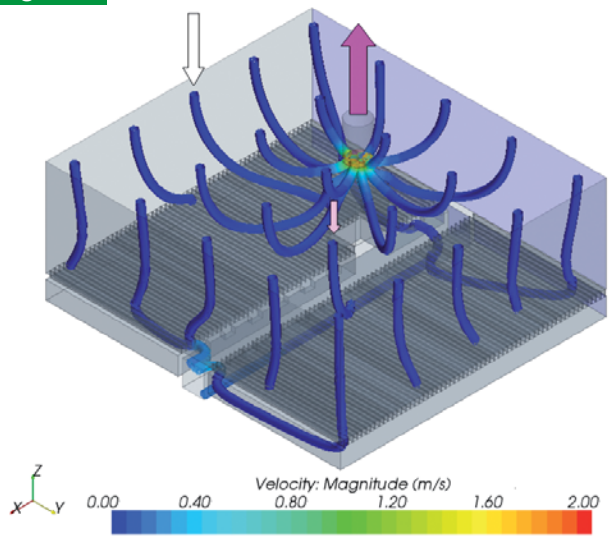
If one works with post connected filter technology with partial under floor suction the question arises in a new light,

Fig. 5



Fresh air (white arrow) moves from the stall ceiling through the stall room in streamtubes. It is sucked through the pore ceiling into the stall (over floor suction) and is thrown out by a central ventilator (purple arrow), compare figure 4.

Fig. 6



To the suction over floor (85 %) an under floor suction (15 %) is added. Particles reach the under floor area much more at the border zones (little arrow) than underneath the ventilator. The under floor suction occurs by a central under floor channel.

whether the pig production must act as a stopgab with regard to the minimization of emission in comparison with cattle and poultries. In many administrative districts of Lower Saxony pig fattening plants are covered with complete filters for emission reduction, while animal protection plays a subordinate role. Indeed it is so that flow mechanical concepts are left aside in poultry plants though here the highest air exchange rates are to observed.

Literature

[1] Krause K-H, Linke S, Mußlick M (2005) Computergestützte Simulation einer raumlufttechnischen Anlage für einen Schweinemaststall mit 2000 Tierplätzen zwecks Optimierung wichtiger Stallklimafaktoren und Minimierung von Ammoniakfreisetzungen. In: Hoch C (ed) 7. Tagung Bau, Technik und Umwelt in der landwirtschaftlichen Nutztierhaltung 2005 : 1.-3. März 2005 in Braunschweig. Münster-Hiltrup : KTBL-Schriftenvertrieb im Landwirtschaftsverlag, pp 289-294.

[2] Krause, K-H, Linke, S, Müller, H-J und M Mußlick (2007): Distribution of ammonia in swine houses at emission reduction. In: Ammonia emissions in agriculture, ed. Monteney, G.-J. und E. Hartung. Wageningen, pp. 134 - 135.

[3] Desta T Z, van Buggenhout S, van Brecht A, Meyers J, Aerts J-M, Baelmans M, Berckmans D (2004): Modelling mass transfer phenomena and quantification of ventilation performance in a full scale installation. Building and Environment.

[4] Weinkauf T, Theise H, Hege H-C and Seidel, H-P (2004). Topological construction and visualization of higher order 3D vector fields. Eurographics, Vol. 23 (3).

[5] Weihs C (2006): Modell- und Praxisuntersuchungen zum Emissionsverhalten von zwei Schweinemastställen. Diplomarbeit, Fachschule Braunschweig/Wolfenbüttel. Wintersemester 05/06.

[6] Zhang, G, Bjerg, B. Strom, J.S., Morsing, S., Kai, P., Tong, G. und P. Ravn (2008): Emission effects of three different ventilation control strategies – A scale model study, Biosystems Engineering, Vol. 100, Heft 1, Mai, S. 96 - 104.

Authors

Dr.-Ing. Karl-Heinz Krause is member of the scientific, **Stefan Linke** member of the technical staff at the von Thünen-Institut (vTI), Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei, Institut für Agrartechnologie und Biosystemtechnik (director: Prof. Dr.-Ing. A. Munack and Prof. Dr. K.-D. Vorlop), 38116 Braunschweig, Bundesallee 50; e-mail: karlheinz.krause@vti.bund.de or stefan.linke@vti.bund.de.

Dr.-Ing. Hans-Joachim Müller is member of the scientific staff at the Leibniz-Institute für Agrartechnik Potsdam-Bornim e.V. (ATB), Max-Eyth-Allee 100, 14469 Potsdam, e-mail, hmueller@atb-potsdam.de

Dr. Michael Mußlick, Thüringer Ministerium für Landwirtschaft, Naturschutz und Umwelt, Beethovenstraße 03, 99096 Erfurt, e-mail: michael.musslick@tmlnu.thueringen.de